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Health and Environmental Risks: An Empirical Study on the Household Solid Waste Management in Panama†

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Abstract

This paper provides empirical evidence of how inefficient solid waste management (SWM) methods can exacerbate public health issues, particularly the incidence of diarrhea in children—one of the leading causes of death among children aged 0 to 4 in Panama. Additionally, it is found that infrequent solid waste collection services and indiscriminate furniture disposal increase the probability of dengue and diarrhea for household members and lead to blocked drains and floods.

We conducted this research using repeated cross-sectional data from the Living Standards Measurement Surveys, covering 7,640 children aged 0 to 4. To broaden our contributions, we collected data through a face-to-face survey of 154 households in Panama City. The findings underscore the urgent need to prioritize improved solid waste collection services and consistent access to tap water, which can help reduce the incidence of diarrhea in children and prevent floods and drainage blockages across the country.

Keywords: Solid waste management, children's diarrhea, health, environmental pollution

JEL classification: D1, Q5, Q53, Q56, Q58

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1. Introduction

Every year, humans generate over 2 billion tons of municipal solid waste globally, a number projected to rise to 3.4 billion tons by 2050 (World Bank, 2018). In developing countries like Panama, where infrastructure struggles to keep pace with solid waste generation, this escalation poses severe challenges to public health, environmental sustainability, and economic stability. In 2023, around one-quarter of Panamanian households inadequately manage solid waste by burning, burying, or illegally dumping it. Even though most households have access to waste collection services, they mostly report receiving an infrequent service because of a shortage of waste collection vehicles and escalating solid waste volumes. Moreover, local governments, which are in charge of the administration of solid waste collection, face numerous challenges in implementing sustainable and practical solutions as only 5% of solid waste is recycled in the country.

Poor waste management contributes to the spread of diseases such as diarrhea, the world's third leading cause of death in children under the age of five. In Panama, it is also a leading cause of infant mortality and morbidity, with 24.3 deaths per 100,000 children under the age of five (Yard Foster et al., 2021). In addition, there is evidence that diarrhea can affect cognitive development independent of stunting with repeated gut infections leading to an increased risk of developing obesity and other related diseases (Wierzba and Muhib, 2018). For this reason, experts point out that proper waste management can curb the spread of diarrheal pathogens that thrive in unsanitary conditions, thus lowering morbidity and mortality rates, combined with enhanced sanitation, water quality, and hygiene education (World Health Organization, 2024).

Given the gaps in the literature, this paper examines how SWM methods affect the probability of children aged 0 to 4 suffering from diarrhea, identifying which disposal methods pose the greatest threat. Additionally, we explore the risk of disease and flooding for individuals who receive infrequent waste collection services, leading to waste accumulation in residential areas of Panama City. This is crucial for Panama and other developing countries, where many households resort to harmful waste management practices when public services are inadequate. Often, families are unaware of the consequences of improper disposal of solid waste. At the same time, local authorities may lack sufficient evidence or motivation to restrict certain methods and prioritize improvements to collection services. Therefore, we aim to provide compelling evidence for policy measures that help reduce the health and environmental risks associated with poor SWM.

To achieve this goal, we first use repeated cross-sectional data from Panama's Living Standards Measurement Surveys (LSMS) on 7,640 children in 1997, 2003, and 2008. Based on information about individual reported cases of diarrhea, household waste management methods, and other relevant characteristics, we determined the effect of each solid waste disposal method (private collection, backyard dumping, burying/burning, illegal dumping) on the probability of children experiencing diarrhea, compared to those with access to public collection services.

Second, to expand our analysis on the importance of public solid waste collection services, we conducted a face-to-face survey in 2023, gathering data on waste management practices from 154 households in Panama City. Using this cross-sectional data, we assessed how the frequency of waste collection affects the probability of household members contracting diseases related to poor waste management practices, such as diarrhea and dengue. Additionally, we examined how infrequent collection contributes to the incidence of floods or blocked drainage in the streets where these households are located.

Our findings reveal that children in households using backyard disposal or private collectors face a significantly higher risk of diarrhea compared to those with access to public collection services. Moreover, when analyzing the impact of collection service frequency, we demonstrate that sporadic service contributes to the accumulation of solid waste around living areas, creating disease vectors and exacerbating blocked sewage and flooding during Panama City's rainy season. We specifically find that consistent access to tap water can significantly reduce the risk of disease in households with less frequent waste collection. Additionally, we observe that the indiscriminate disposal of furniture significantly increases the likelihood of flooding in residential areas.

Previous literature explores the harmful impacts of inadequate SWM practices on developing countries in Asia and Africa, mainly using correlation and percentage comparison analyses within health and environmental science studies. Research such as McClelland et al. (2022) highlight the issue of childhood diarrhea, with determinants including improper waste disposal and lack of toilet facilities. Abubakar et al. (2022) review SWM practices in rapidly urbanizing cities, noting that mixing household and hazardous waste leads to severe pollution and higher public health costs. Similarly, studies by Kurniawati et al. (2021) and Banerjee et al. (2013) correlate household characteristics and waste management practices with disease vectors while Agya et al. (2024) discuss the challenges of enforcing sustainable practices in Ghana. Moreover, Baddianaah (2023) and Lamond et al. (2012) highlight that flooding poses a major challenge in cities, particularly in developing countries, and that comprehensive municipal programs and community-based schemes are necessary to manage flood risks effectively.

Despite this broad contribution, econometric analyses directly linking children's health outcomes to SWM are scarce. Most of the literature centers on the impacts of sanitation and pollution, where exposure to improper sanitation is significantly associated with effects on children's height and diarrhea incidence (Cameron et al., 2019; Deutschmann et al., 2023; Spears, 2020). Furthermore, Orgill-Meyer and Pattanayak (2020) show that improved sanitation boosts children's cognitive scores, especially among girls, while Augsburg and Rodríguez-Lesmes (2018) find that sanitation coverage reduces child stunting in Northern India. Alves and Belluzzo (2004) demonstrate the significant impact of sanitation, education, and income on reducing infant mortality in Brazil. Studies by Garg et al. (2018), Li et al. (2020), and Ogunrinola and Adepegba (2012) explain the role of sanitation in preventing diseases and the health risks from waste pollution. Brueckner (2013) is the only econometric study that discusses how specific household characteristics, including poor SWM practices and neglected yards, affect the health of its members. However, his study does not make distinctions between solid waste methods or focus on diseases related to poor SWM and children's health.

To our knowledge, our research is the first econometric analysis of how different SWM methods affect the incidence of diarrhea in children, as well as the first to investigate the role of solid waste collection services' frequency in the occurrence of diseases, blocked sewage, and flooding.

The rest of this paper is organized as follows: Section 2 provides the background and previous literature, Section 3 outlines the empirical strategy, Section 4 presents our main results, Section 5 discusses the effects of solid waste disposal collection frequency in Panama City, and Section 6 concludes with policy implications.

2. Background and Previous Literature

Inadequate SWM is Panama's second major environmental issue, with an estimated daily production of 1.2 kg of garbage per capita. Only 65% of this waste reaches landfills, while the remainder often ends up either in illegal dumps, incinerated, or buried, leading to substantial environmental degradation and health risks (United Nations Development Programme, 2023). Despite having access to public collection services, most households face significant challenges due to the lengthy intervals between collection days. Solid waste accumulates inside or near houses for several days, attracting rodents and insects that can spread diseases. Additionally, infrastructure issues worsen as improperly managed solid waste obstructs sewers, rivers, and streams, causing floods, economic losses, and traffic congestion during the rainy season (Ministerio de Obras Públicas, 2020). Aggravating this scenario is the minimal recycling rate of 5%, resulting in various types of waste, including plastic containers, food, and electronic devices with toxic materials, being disposed of together without sorting. Once this waste reaches the landfills, it generates significant air, soil, and water pollution due to the lack of proper and organized treatment facilities (Murillo, 2021).

Various medical and public health research in developing countries have documented the harmful effects of inadequate SWM practices on health. Asfaha et al. (2018) discuss how the lack of toilet facilities, improper waste disposal, and unprotected drinking water significantly contribute to childhood diarrhea in Ethiopia. Similarly, McClelland et al. (2022) found that the 25.6% prevalence of diarrhea among children under five in Tanzania can be reduced through protective factors, including dedicated drinking water storage and improved waste management. In terms of rapidly urbanizing cities, Abubakar et al. (2022) reviewed practices like mixing household and hazardous waste, inadequate storage, and uncontrolled disposal result in significant air, and water pollution and land degradation, imposing significant public health costs for marginalized social groups.

Studies in environmental science such as, Kurniawati et al. (2021) found that in Indonesia, factors such as floor type, latrine condition, waste management, and water sources significantly influence diarrhea prevalence in toddlers in poor communities. While Banerjee et al. (2013) identified household waste containers in India as noteworthy larval habitats for dengue vectors, Aedes aegypti and Aedes albopictus. Agya et al. (2024) offer a discussion of the diverse traditional waste management systems and positive perceptions of sustainable practices in Ghana and how, despite these perceptions, they still exhibit poor practices due to a lack of enforcement and facilities. Other researchers discuss that SWM and flooding pose challenges for developing countries and cities worldwide with limited knowledge of flood mitigation. Baddianaah (2023) shows that the primary causes of floods in Liberia are poor urban planning, inadequate drainage, poor waste management, and weak law enforcement. They underline that African city planners need to address these controllable human factors to achieve sustainable urban development to mitigate flood risks. Comparably, Lamond et al. (2012) emphasize advocating for large municipal programs and community-based schemes within integrated flood management strategies.

These studies provide key insights; however, most results rely solely on anecdotal evidence or descriptive statistics, using correlation matrices and percentage comparisons to support their discussions. Only a few use statistical models, but they do not include economic variables, and they address the differences between SWM practices as proper or improper without exploring different methods. Therefore, our econometric analysis focuses on different solid waste disposal methods, identifies robust causal relationships, and informs policy implications.

When using econometric models, the literature mainly explores the effects of sanitation and environmental pollution on health measurements. Augsburg and Rodríguez-Lesmes (2018) and Orgill-Meyer and Pattanayak (2020) demonstrate that increased village latrine coverage significantly boosts children's cognitive test scores, and reduces child stunting, benefiting girls especially. Likewise, Spears (2020) proves that access to sanitation explains height differences between children from India and Africa. In contrast, in rural communities of Indonesia, the introduction of a sanitation intervention that led to increased toilet construction did not impact children's height but did reduce roundworm infestations (Cameron et al., 2019). Meanwhile, Deutschmann et al. (2023) examine how rates of diarrhea in children in Senegal decreased following the privatization of sewage treatment centers. Improvements in sanitation, education, and income have been found to significantly reduce infant mortality in Brazil and Indonesia, highlighting the need for diverse municipal policies and the importance of sanitation in preventing waterborne diseases (Alves and Belluzzo, 2004; Garg et al., 2018).

The literature also discusses the effects of improper treatment of solid waste. Li et al. (2020) report that emissions from waste disposal sites increase migrants' sickness in Beijing by 10-11%. Additionally, Shi and Zhang (2023) note that China's 2017 waste import ban improved air quality, specifically in areas with poor waste management. In Nigeria, Ogunrinola and Adepegba (2012) demonstrated that poorly managed disposal dumps significantly impact health and labor supply, calling for better waste management policies.

When applying an econometric approach, the most similar study to ours is by Brueckner (2013), which explored how household structural characteristics, such as the absence of garbage services, poorly maintained yards, and stagnant water near dwellings, increase sickness rates in Indonesia. However, this study does not focus on analyzing different SWM systems and practices. Therefore, our study aims to contribute by discussing the multiple mechanisms of the relationship between children's diarrhea incidence and household solid waste methods.

Our discussions emphasize the importance of developing better strategies for managing household solid waste to reduce negative health and environmental effects, as well as providing strong evidence for developing effective policy recommendations. In this context, the literature also enables us to mention alternatives that could help reduce the generation of solid waste, such as adopting a circular economy approach. These principles can guide our understanding of how various SWM strategies have been implemented and re-evaluated in developed countries, including plastic bottle recycling, proper treatment of electrical and electronic equipment, and the reprocessing of multiple waste materials (Lahcen et al., 2022; Mazzarano, 2022; Zając and Avdiushchenko, 2020; Zhou and Smulders, 2021). In Panama**,** household motivations to engage in recycling practices are unknown, and the lack of strict solid waste regulations contributes to severe environmental and health problems. We briefly explore the main drivers of recycling participation in Panama and what alternatives could be considered to overcome recurrent obstacles.

3. Empirical Strategy

3.1 Model

To assess the heterogeneous impact of solid waste methods on diarrhea incidence in children, we estimate the following linear probability model:

$$H_{ijt} = \sigma DM_i + \gamma X_i + \delta_j + \pi_t + \varepsilon_{ijt} \quad (1)$$

Where H_{ijt} denotes the occurrence of diarrhea in a child (i) aged 0 to 4 years in district (j) and year (t) and takes a value of 1 if the child has suffered from the condition. DM_i represents the primary solid waste disposal method in the household where the child lives (private collection, illegal dumping, disposal in own backyard, burial/burning) using the public collection as the reference category. X_i is a vector of relevant characteristics of the child and their household, such as the child's age, household consumption per capita (logged), hours of tap water, toilet access, education level and age of the householder, and the number of people living in the household. District and year-by-province specific fixed effects are represented by δ_j and π_t respectively, finally, ε_{ijt} is the error term.

In Panama, the availability of public collection services is influenced by factors such as municipal planning and regional policies. These services are provided equally to all households within designated areas, and due to the lack of strict regulations to monitor service usage or payments, even households that do not pay for the service can still utilize it[3]. Therefore, if a household reports using public collection services, it is inferred that they reside in an area covered by these facilities, and other households in the same area are likely to use the same method. Households served by this service typically place their solid waste outside their dwelling if it is next to a road accessible to the collection truck. Those on streets or paths inaccessible to the truck use the nearest common dumpsite or place their waste on the side of a street where the truck passes. In areas where public collection is unavailable but still accessible by road, private collection services are sometimes used. These are often provided by neighbors or individuals who use their cars to collect solid waste sporadically for a small fee. Illegal dumping refers to those who dump their solid waste in rivers or on empty land, depending on the proximity of households to these sites this could impact or not their health. Backyard disposal refers to households discarding their solid waste in their backyards without any kind of treatment, while burying or burning waste indicating that households choose to manage their waste by burying or burning it in their backyard.

Previous literature on sanitation and health addresses the presence of endogeneity in their analyses since household behaviors and perceptions could simultaneously influence infrastructure investments and health outcomes. However, in Panama's SWM context, households typically lack direct control over whether to receive public collection services, which minimizes these concerns. On the other hand, households that use other methods (private collection, backyard disposal, burying/burning, and illegal dumping) are more reflective of household-level decisions; therefore, we include controls for key variables that capture socioeconomic and infrastructural differences. For example, households that use gas for

[3] Starting in 2015, the local government of the district of Arraijan in the province of Panama Oeste implemented a system in some communities where households with up-to-date collection service payments can place a sticker outside their homes to ensure their solid waste is collected. However, the implementation of this policy does not affect our results, as we are using data from before this period.

cooking can indicate if a house has road accessibility, allowing garbage collection trucks or private cars to pass nearby[4]. In the same way, homeownership status[5], is determined by long-term financial and personal decisions, which is linked to improvement in infrastructure and better health outcomes. Furthermore, composite households, or those with more than one family living under the same roof, benefit from greater community links improving access to information and resources for controlling health concerns. The inclusion of these factors and incorporating district and province-by-year fixed effects substantially reduce endogeneity issues in our analysis.

3.2 Data

To analyze the impact of household solid waste practices on children's health, we use data from Panama's Living Standards Measurement Surveys (LSMS), a collaborative effort by the World Bank and Panama's Ministry of Economics and Finance. This dataset provides repeated cross-sectional information with insights into children's health and family waste disposal practices. We focus on data concerning children aged 0 to 4, compiled in 1997, 2003, and 2008, encompassing 7640 individuals. Given the absence of direct income measures in the majority of observations, we use real per capita household consumption as a proxy for income.

Table 1 exhibits that about 24% of children aged 0-4 experienced diarrhea in the month before the survey collection. Furthermore, we observe that 36% of children live in households with access to public collection, while 37% bury or burn their solid waste.

Table 1. Descriptive statistics: LSMS

Variable	N	Mean	SD	Min	Max
Child had diarrhea	7640	0.24	0.43	0	1
Waste Disposal Method					
Public Collector	7640	0.36	0.48	0	1
Private Collector	7640	0.08	0.28	0	1
Illegal dumping	7640	0.12	0.33	0	1
Backyard	7640	0.07	0.25	0	1
Bury/burn	7640	0.37	0.48	0	1
Age	7640	1.98	1.42	0	4
Real consumption per cap (USD)	7640	1408.73	1536.25	38.8	18288.03
Hours of tap water	7640	482.8	306.98	0	720
Toilet access	7640	0.39	0.49	0	1
Householder's education	7640	7.65	4.54	0	18
Householder's age	7640	41.84	13.7	0	98
No. of members per household	7640	6.69	3.47	2	25
Use gas for cooking	7640	0.67	0.47	0	1
Composite households	7640	0.32	0.47	0	1
Homeownership	7640	0.77	0.42	0	1
Years in current residence	7640	42.36	39.98	0	98

Notes: Consumption per capita is calculated using 2010 = 100. Hours of tap water are based on monthly self-reported data; households that obtain water through methods other than pipe systems are assigned a value of zero, accounting for approximately 14% of the observations in our analysis.

[4] In Panama the majority of households are responsible for obtaining their cooking gas cylinders, typically refilled at local stores that require road accessibility.

[5] Homeownership is determined by whether a household fully owns their home or is paying a mortgage.

4. Main Results

The estimation results in Table 2, Column 1 show that using private collection services for solid waste disposal is associated with an increased probability of diarrhea in children. While using private collection may seem like a more feasible and better option than public collection, it is important to note that private services are not regulated in Panama, therefore the lower collection frequency compared to public services can lead households to store solid waste for extended periods, which could contribute to the generation of vector-borne diseases, thereby increasing health risks. Additionally, these results should be interpreted with caution, as the public collection may appear less harmful in this context but still presents significant environmental and health risks in some areas of the country. Therefore, we emphasize that it is crucial to ensure the availability of public waste collection services, with greater frequency and organization, to effectively reduce the adverse health impacts associated with any SWM method.

We also find that backyard disposal is associated with a 9% higher incidence of diarrhea in children than public collection, likely due to direct exposure to untreated waste in living areas, which can facilitate the spread of diseases and environmental pollutants. These results provide clear evidence of the health risks associated with suboptimal waste disposal and align with previous research in health and environmental sciences (Asfaha et al., 2018; Kurniawati et al., 2021). Furthermore, it is consistent with the econometric analysis of household members' health by Brueckner (2013) where it is mentioned that poorly maintained backyards can affect individuals' health.

Further estimations reveal that household homeownership, a proxy for socioeconomic status, represents a decrease in the probability of diarrhea in children. This suggests that higher-income households or those who own their houses may have better access to sanitation and hygiene resources. Additionally, the education level and age of the household head are inversely related to the incidence of diarrhea, reflecting greater knowledge and implementation of hygienic practices and more experienced or cautious health-related behavior among older adults[6].

[6] In Appendix Table A1, we aggregate all non-public collection methods into a single category to analyze the difference in impact between having access to public collection services and not. The results show that children in households without public collection services have a 2% higher probability of experiencing diarrhea.

Table 2. Effects of household's solid waste disposal methods on the probability of diarrhea in children

	(1)	(2)	(3)
Disposal method. *Reference: Public collection*			
Private collection	0.0374*	0.0420**	0.0704***
	(0.0206)	(0.0192)	(0.0186)
Illegal Dumping	0.00199	0.0298	0.0376*
	(0.0247)	(0.0223)	(0.0217)
Backyard	0.0909***	0.0950***	0.110***
	(0.0281)	(0.0273)	(0.0269)
Bury / Burn	0.0164	0.0148	0.0206
	(0.0160)	(0.0148)	(0.0141)
Age	-0.0230***	-0.0226***	-0.0223***
	(0.00326)	(0.00326)	(0.00328)
Log total consumption per cap(USD)	0.00180	-0.00120	-0.0162*
	(0.00950)	(0.00933)	(0.00928)
Hours of tap water	0.0000136	0.0000112	-0.0000141
	(0.0000186)	(0.0000180)	(0.0000176)
Toilet access	-0.0301**	-0.0263*	0.00555
	(0.0143)	(0.0140)	(0.0136)
Householder's education	-0.00389**	-0.00417***	-0.00598***
	(0.00154)	(0.00152)	(0.00152)
Householder's age	-0.000963**	-0.00107**	-0.00144***
	(0.000415)	(0.000414)	(0.000413)
No. of members per household	0.00570***	0.00680***	0.00967***
	(0.00201)	(0.00199)	(0.00198)
Use gas for cooking	-0.0214	-0.0349**	-0.0343**
	(0.0169)	(0.0160)	(0.0159)
Composite households	-0.0511	-0.0531	-0.0223**
	(0.0347)	(0.0349)	(0.0103)
Homeownership	-0.0453***	-0.0459***	-0.0486***
	(0.0127)	(0.0125)	(0.0125)
Years in current residence	-0.000183	-0.000117	-0.000199
	(0.000132)	(0.000130)	(0.000128)
District FE	Yes	No	No
Year by province FE	Yes	Yes	No
Observations	7640	7640	7640
R^2	0.081	0.068	0.043
F	10.14***	13.03***	23.08***

Notes: Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Estimators are shown to be robust under different regional and time control specifications.

5. Effects of Solid Waste Collection Frequency

5.1 Specification

To further explore how inefficient solid waste collection services affect health, we target an analysis in Panama City, where households have the highest amount of solid waste generation and face the most significant public health challenges in the country. We also explore how collection services inefficiencies contribute to blocked drainages and floods. For this purpose, we estimate:

$$Y_h = \partial_0 + \omega X_h + \varphi + u_h \ (2)$$

In model (2), Y_h is a binary outcome indicating whether any household members had diseases linked to poor SWM, such as dengue and diarrhea, or if they have experienced blocked drains on their street or flooding around their areas in the last three years. The vector X_h includes variables such as frequency of collection services, sources of information, methods of furniture disposal, weekly access to tap water, and demographic details of the person managing the waste. It also includes logged household income, whether they have received waste management education, and the number of household members. District controls are denoted by φ, and u_h is the error term.

To estimate the effect of collection frequency, we use a dummy variable set to one if the household receives waste collection once a week or later, and zero if they receive collection services multiple times per week. Additionally, we incorporate a continuous variable representing the number of weeks between households' disposal of solid waste and when they receive collection services. In Panama, due to the irregularity of solid waste public collection services, many households place their solid waste outside even when the collection truck is not scheduled to arrive for several days.

5.2 Solid Waste Practices Survey

To estimate model (2), we collected a face-to-face survey from November 20th to December 8th, 2023, targeting the densely populated Panama and San Miguelito districts[7]. The study utilized a disproportionate random stratified sampling method, assigning an equal number of six households from each of the 35 corregimientos[8] within Panama City. The initial sampling included 210 households selected by the Google Earth Engine platform[9]. After thoroughly data cleaning and removing incomplete responses, we finalized a cross-sectional dataset of 154 households. Our survey protocol stipulated that non-participating households would be replaced by the following random selection, thus preserving sample integrity. In addition, we recognize that equal allocation across corregimientos can increase sampling error, especially within more populated areas, therefore, we applied statistical weighting techniques, aligning the influence of each corregimiento with its actual population size and reinforcing the reliability and validity of our results[10]. This approach ensured a balanced representation of each corregimiento's waste management practices.

[7] According to the 2023 Household and Population Census, 92% of households in the district of Panama and 99% in San Miguelito reported having access to solid waste collection services. Observations from our survey showed that 148 households used public waste collection services, while only 6 relied on private collectors. This is why our analysis focuses primarily on public collection services.

[8] Corregimientos is the regional subdivision following districts.

[9] Appendix Figure A4 shows the map of the corregimientos included in our analysis while Figure A5 provides a glance at the selection method of households in the platform of Google Maps.

[10] Appendix Table A5 shows the sample allocation of the corregimientos included in our analysis.

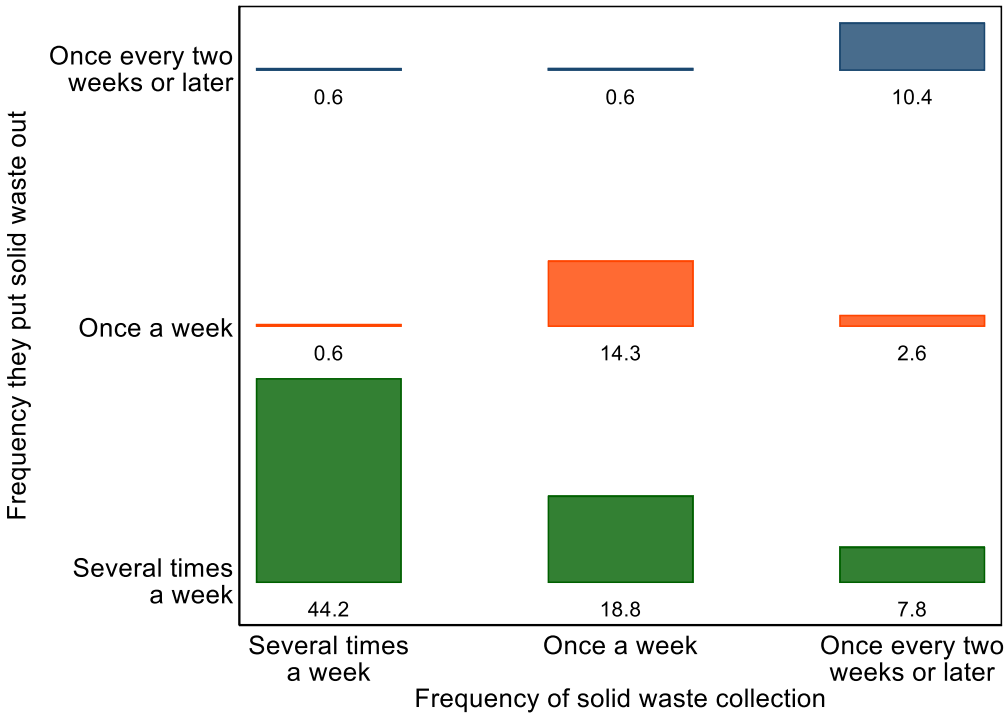
Table 3 reveals that approximately 23.4% of respondents experienced diseases associated with solid waste in the last three years. Floods occurred for 9.7% of the participants, 18.2% reported that drains on their streets got blocked, and 55% of households receive collection services once a week or later. Moreover, 25.3% of the respondents practiced recycling[11]. We include an extensive outline of the methodologies employed for data collection and the questionnaire in Appendix sections A5 and A6. As depicted in Figure 1, we analyze the relationship between household solid waste disposal frequency and solid waste collection services in Panama City. The horizontal axis categorizes the collection frequency as "Several times a week," "Once a week," and "Once every two weeks or later." The vertical axis indicates the frequency with which households dispose of their solid waste using the same intervals. Each cell in the grid corresponds to the percentage of households that fall into each combination of disposal and collection frequencies. For instance, if a household disposes of waste multiple times within a week and collection occurs that same week, the variable is assigned a value of zero. If waste is disposed of several times a week and collected one week later, the variable is set to one. If collection occurs two weeks or more after disposal, the variable is set to two. Given these conditions, we observe that 44.2% of households dispose of waste several times a week and have it collected several times a week. Another 18.8% of households dispose of waste several times a week but have it collected only once a week.

Table 3. Descriptive statistics: Solid waste practices survey

Variable	N	Mean	SD	Min	Max
Experienced disease associated with solid waste	154	0.21	0.41	0	1
Drainage gets blocked on the street	154	0.18	0.39	0	1
Flood happened in the last 3 years	154	0.1	0.3	0	1
Less frequent collection	154	0.55	0.5	0	1
Time between disposal and collection					
Same week	154	0.71	0.46	0	1
1 week	154	0.2	0.4	0	1
2 weeks or more	154	0.09	0.29	0	1
Indiscriminate furniture disposal	154	0.28	0.45	0	1
Weekly hours of tap water	154	137.74	56.19	0	168
Practice recycling	154	0.25	0.44	0	1
Age of person in charge of disposing of solid waste	154	41.34	17.69	10	80
Received any information or training on sorting	154	0.06	0.24	0	1
Household's income	154	868.92	419.16	100	3000
Number of members in the household	154	3.73	2.41	1	24
Receive money from recycling	154	0.06	0.24	0	1

[11]In Appendix Figure A1, we observe that while the vast majority of households dispose of their furniture indiscriminately, 21.4% use bulk waste collection services, and 17.5% give it to others. Similarly, Figure A2 shows that 67.3% of people dispose of electronic waste with regular household waste, while 19% choose to keep it at home. Figure A3 shows that households that recycle are more inclined to recycle metal (35.9%) or plastic (33.3%).

Figure 1. Percent distribution of households by solid waste disposal and collection frequencies



Note: This figure is based on data from the Solid Waste Practices Survey of 154 households in Panama City. It highlights that nearly 30% of households dispose of their solid waste outside, even when the next collection service is scheduled for a week or later.

5.3 Results

In Table 4, we analyze self-reported occurrences of dengue and diarrhea among household members and the frequency of collection services in Panama City. Additionally, recognizing that disease occurrence can be influenced by both waste management practices and water service availability, which affects hand and food washing frequency (McClelland et al., 2022), we examine how the combination of waste collection frequency and weekly hours of tap water access impacts the probability of waste-related diseases in households across Panama's capital districts of Panama and San Miguelito.

We observe that having access to less frequent collection services does not have a statistically significant effect on the probability of disease of household members, however, results in column 2 demonstrate this effect differs among households with different access to tap water, whereas households with fewer hours of tap water and less frequent collection services have a higher probability of contracting diseases. Figure 2 provides a closer look at the decreasing marginal heterogeneous effect of less frequent collection services by each hour of water access, we observe that increasing hours of tap water reduces the negative effect of infrequent solid waste collection services. This underscores the importance of water availability, especially where solid waste services are less regular[12].

Table 4 also shows that indiscriminate furniture disposal contributes to a higher probability of disease experience. As discussed by previous literature in other developing countries

[12] Results comparing different levels of collection frequency are shown in Appendix Table A2. The estimators for receiving collection services once a week and once every two weeks or more are statistically significant, with similar impact differences compared to the reference group. Moreover, we do not observe a statistically significant effect from the intervals between disposal and collection.

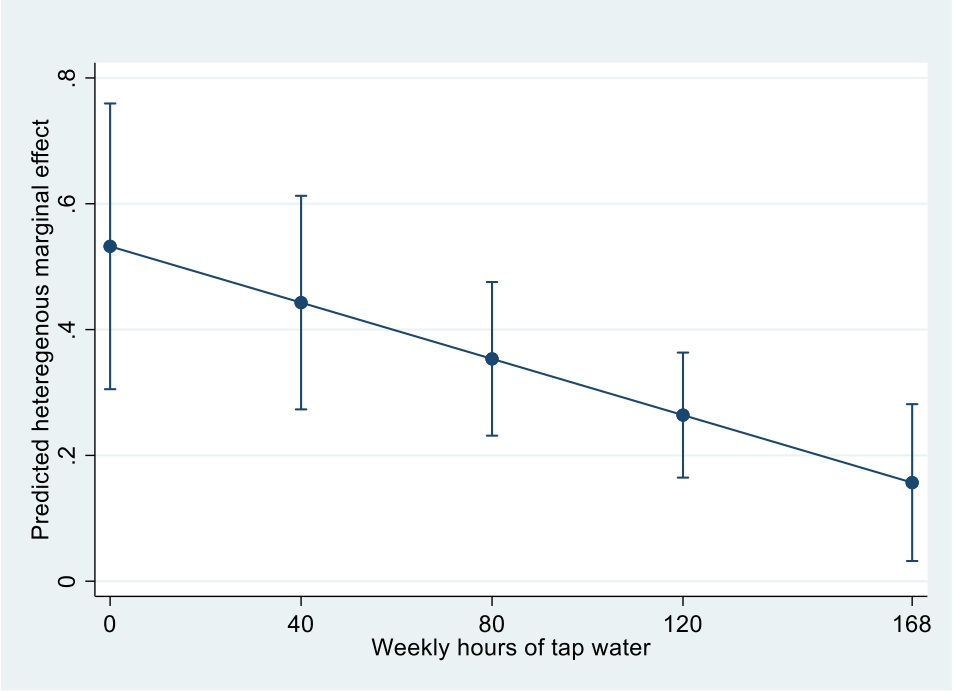
(Banerjee et al., 2013; Krystosik et al., 2020), there is a correlation between the type of solid waste being disposed of and the propagation of insects like Aedes mosquitos, therefore our results provide further evidence of bulky waste creating a suitable environment for disease transmitters.

Table 4. Effects of collection frequency on disease probability in Panama City

	(1) Experienced disease associated with solid waste	(2) Experienced disease associated with solid waste
Less frequent collection	-0.0330	0.490**
	(0.0797)	(0.205)
Weekly hours of tap water	-0.00202**	0.00102
	(0.000792)	(0.00103)
Less frequent collection# Weekly hours of tap water		-0.00325**
		(0.00138)
Indiscriminate furniture disposal	0.186**	0.181**
	(0.0876)	(0.0877)
Age of person in charge of disposing of solid waste	0.00184	0.00177
	(0.00287)	(0.00290)
Log (household income)	0.127*	0.133*
	(0.0717)	(0.0727)
Education of person in charge of disposing of solid waste	0.00426	0.00393
	(0.0130)	(0.0130)
National TV news	-0.0589	-0.0505
	(0.100)	(0.102)
Newspaper (online, physical)	0.277	0.280
	(0.237)	(0.228)
Radio	0.740***	0.733***
	(0.183)	(0.184)
Number of members in the household	0.0174	0.0182
	(0.0185)	(0.0182)
Observations	154	154
R^2	0.213	0.222
F	5.034***	4.706***

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Less frequent collection represents households receiving solid waste collection services once a week or later. The main source of the information they receive base category is "social media". District controls are included.

Figure 2. Heterogeneous marginal effect of less frequent garbage collection



Notes: The figure is constructed using estimator results from Table 4, Column 2. Predicted marginal effects on disease probability are interpreted as compared to households that receive solid waste collection services several times in a week.

In Table 5, we explore the impact of waste collection frequency and household behaviors on local drainage problems and flooding, which are persistent concerns during the rainy season in Panama City. The inclusion of household characteristics into this analysis is fundamental for understanding the multifaceted impact of socio-economic variables on urban infrastructure challenges. Household income serves as a proxy for the economic status of an area; wealthier neighborhoods typically benefit from better-maintained infrastructure, which can mitigate flood risks. Information on waste sorting reflects the effectiveness of governmental waste management programs targeting specific communities, aiming to elevate local practices and awareness. Additionally, the number of household members correlates with greater community engagement and potentially improves collective waste disposal practices, which are crucial in preventing drainage blockages.

We observe that households with less frequent collection services are more likely to experience blocked drainage in the street where they live[13]. Column 2 expands on this by examining the duration for which waste is left out before collection. The findings imply that when solid waste is placed outside dwellings and collection is not scheduled for another week, there is a greater likelihood of blocked drains. This may be worsened by animals scattering the waste, which can be washed into storm drains during rainfall.

Analysis of flood occurrences in column 3 reveals that indiscriminate furniture disposal, which includes households that dispose of their furniture on the streets, nearby landfills, or waterways, is linked with a heightened risk of flooding. Given that furniture disposal in rivers and streams is a noted contributor to blockages leading to floods in some areas of Panama City,

[13] We find similar results when using different categories of infrequent collection. Appendix Table A3, Column 1 indicates that households receiving waste collection services only once a week are 12% more likely to experience blocked drainage on their streets compared to those serviced multiple times weekly. Furthermore, households with services extending to once every two weeks or less frequently face a 14% higher probability of drainage blockage.

the evidence aligns with established causative factors for urban flooding (Ministerio de Obras Públicas, 2020).

Table 5. Effects of collection frequency on drainage problems and flood probability

	(1) Drainage gets blocked on the street	(2) Drainage gets blocked on the street	(3) Flood happened in the last 3 years	(4) Flood happened in the last 3 years
Less frequent collection	0.132**		0.0347	
	(0.0579)		(0.0336)	
Indiscriminate furniture disposal	0.0823	0.147**	0.184***	0.200***
	(0.0793)	(0.0738)	(0.0663)	(0.0688)
Period between disposal and collection		0.167***		0.0399
		(0.0619)		(0.0437)
Information or training on sorting	0.157	0.108	-0.113*	-0.124**
	(0.149)	(0.152)	(0.0629)	(0.0609)
Log (household income)	-0.175**	-0.153**	0.0501	0.0553
	(0.0721)	(0.0692)	(0.0489)	(0.0496)
Number of members in the household	0.0125	0.00518	-0.00616	-0.00785
	(0.0160)	(0.0152)	(0.00993)	(0.0102)
Observations	154	154	154	154
R^2	0.259	0.294	0.256	0.259
F	6.431***	7.464***	3.462***	3.511***

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The main source of information reference groups is social media. District controls are included.

6. Conclusion and Policy Implications

Our findings demonstrate the significant negative effects of disposing of solid waste around households on children's health. We especially emphasize that collection services pose risks to the health of household members since they are offered discontinuously. We argue that key factors such as providing waste collection to more households, increasing collection frequency, and improving access to essential services like tap water could help reduce the probability of diseases.

Policy recommendations:

- Enhanced waste collection: Waste collection services across all districts are essential since they represent the alternative with the least negative impact on children's health. Once collection services are provided, implementing strict schedules, suitable collection points protected from stray animals, and restrictions for households to not put their solid waste outside before collection, can minimize the accumulation of waste and reduce disease transmission and infrastructure issues. This could also help to reduce the periods when households keep their solid waste inside their dwellings, which could be another mechanism that increases the risk of diseases.
- Monetary incentives for recycling: Financial incentives in areas where the accumulation of solid waste is more noticeable can effectively boost recycling practices[14]. Policymakers should strengthen recycling incentive programs to enhance participation rates and environmental outcomes. This could have economic and environmental benefits for communities willing to participate.
- Infrastructure investment: Addressing the lack of properly assigned waste disposal areas in densely populated areas is critical to avoiding disorganized and uncontrolled disposal. Moreover, it is necessary to invest in better drainage systems and advanced waste treatment technologies that can help accommodate the city's needs and mitigate public health and flooding problems.
- Educational initiatives: While education alone does not significantly reduce disease incidence in our study, it can still encourage responsible waste disposal behaviors. Local governments must invest in education and design campaigns that bring awareness about the impacts of poor waste management while measuring its positive outcomes.
- Integrated urban planning: It is vital to link waste management with urban planning and other essential services. For example, combining water resources and waste management since ensuring reliable tap water access can enhance overall community health.
- Economic models for waste management: In Panama City, there are significant delays in waste collection fee payments; therefore, plans to explore waste pricing models such as pay-as-you-throw (PAYT) are advisable. Previous literature has shown that the responses to such pricing strategies could reduce municipal waste management costs and promote recycling (Valente, 2023).

In summary, enhancing the regularity and efficiency of waste collection services and supporting these with educational and incentive-based recycling programs can significantly improve health and environmental conditions, especially in Panama's capital. Further research should refine these strategies and explore costs and additional factors that optimize health outcomes.

[14] Analysis of the impact of household characteristics on the probability of recycling is provided in Appendix Table A4.

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Appendix

A1. Heterogeneous impact of access to public collection services on children's health

Table A1. Effects of the lack of public solid waste collection services on the probability of diarrhea in children between 0-4 years old.

	(1)	(2)	(3)
Without collection	0.0239*	0.0252*	0.0397***
	(0.0142)	(0.0130)	(0.0124)
Age	-0.0231***	-0.0227***	-0.0224***
	(0.00326)	(0.00326)	(0.00329)
Log total consumption per cap(USD)	0.00224	-0.00275	-0.0184**
	(0.00949)	(0.00929)	(0.00921)
Hours of tap water	0.0000132	0.00000997	-0.0000144
	(0.0000186)	(0.0000180)	(0.0000176)
Toilet access	-0.0255*	-0.0208	0.0171
	(0.0140)	(0.0136)	(0.0131)
Householder's education	-0.00398***	-0.00415***	-0.00597***
	(0.00154)	(0.00152)	(0.00152)
Householder's age	-0.000955**	-0.00106**	-0.00143***
	(0.000415)	(0.000414)	(0.000413)
No. of members per household	0.00584***	0.00706***	0.00996***
	(0.00203)	(0.00200)	(0.00199)
Use gas for cooking	-0.0242	-0.0431***	-0.0414***
	(0.0167)	(0.0155)	(0.0152)
Composite households	-0.0471	-0.0498	-0.0207**
	(0.0345)	(0.0347)	(0.0103)
Homeownership	-0.0465***	-0.0461***	-0.0494***
	(0.0127)	(0.0125)	(0.0124)
Years in current residence	-0.000180	-0.000108	-0.000190
	(0.000132)	(0.000130)	(0.000128)
District FE	Yes	No	No
Year by province FE	Yes	Yes	No
Observations	7640	7640	7640
R^2	0.079	0.066	0.041
F	10.97***	13.61***	27.18***

Notes: Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Estimators are shown to be robust under different regional and time control specifications. Estimator of "Without collection" include households that use either private collection, backyard dumping, burying/burning or illegal dumping.

A2. Effects of frequency of collection on diseases, blocked drainage, and floods probabilities.

Table A2. Effects of collection frequency levels on disease probability in Panama City

	(1)	(2)	(3)	(4)
Once a week	-0.0189	0.473**		
	(0.0911)	(0.225)		
Once every 2 weeks or monthly	-0.0629	0.496*		
	(0.102)	(0.259)		
Weekly hours of tap water	-0.00200**	0.00101	-0.00195**	-0.00213**
	(0.000794)	(0.00104)	(0.000752)	(0.000962)
Once a week # Weekly hours of tap water		-0.00301*		
		(0.00156)		
Once every 2 weeks or monthly # Weekly hours of tap water		-0.00353**		
		(0.00169)		
Period between disposal and collection			-0.0141	-0.0714
			(0.0613)	(0.167)
Weekly hours of tap water # Period between disposal and collection				0.000435
				(0.00112)
Indiscriminate furniture disposal	0.194**	0.187**	0.176**	0.173**
	(0.0878)	(0.0887)	(0.0852)	(0.0855)
Age of person in charge of disposing of solid waste	0.00161	0.00149	0.00183	0.00188
	(0.00291)	(0.00292)	(0.00291)	(0.00292)
Log (household income)	0.125*	0.130*	0.126*	0.123*
	(0.0720)	(0.0731)	(0.0719)	(0.0712)
Education of person in charge of disposing of solid waste	0.00499	0.00493	0.00482	0.00523
	(0.0130)	(0.0130)	(0.0125)	(0.0126)
National TV news	-0.0595	-0.0512	-0.0565	-0.0539
	(0.101)	(0.102)	(0.101)	(0.101)
Newspaper (online, physical)	0.294	0.289	0.260	0.249
	(0.241)	(0.222)	(0.243)	(0.241)
Radio	0.752***	0.735***	0.756***	0.782***
	(0.180)	(0.194)	(0.181)	(0.178)
Number of members in the household	0.0185	0.0187	0.0179	0.0167
	(0.0182)	(0.0181)	(0.0180)	(0.0181)
Observations	154	154	154	154
R^2	0.214	0.224	0.212	0.214
F	4.91***	3.98***	5.08***	5.82***

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The reference group for the frequency of collection is "several times a week". The main source of the information base category is "social media". District controls are included.

Table A3. Effects of collection frequency on drainage problems and flood probability

	(1) Drainage gets blocked on the street	(2) Flood happened in the last 3 years
Frequency of collection		
Once a week	0.127*	0.0128
	(0.0663)	(0.0386)
Once every 2 weeks or monthly	0.144*	0.0874
	(0.0833)	(0.0675)
Indiscriminate furniture disposal	0.0778	0.164**
	(0.0873)	(0.0769)
Period between disposal and collection		
Received any information or training on sorting	0.153	-0.129*
	(0.147)	(0.0669)
Log (household income)	-0.174**	0.0510
	(0.0726)	(0.0491)
Number of members in the household	0.0122	-0.00752
	(0.0159)	(0.00955)
Observations	154	154
R^2	0.260	0.264
F	5.603***	3.270***

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ The reference group for the frequency of collection is "several times a week". District controls are included.

A3. Effects of Socio-economic Characteristics on the Probability of Recycling in Panama City.

In the background and literature review, we explain how the circular economy emerges as a viable strategy to address global waste management deficiencies. Considering Panama's low recycling rates, we examine the determinants of recycling behavior in Panama City. Table A4 highlights a significant positive relationship between receiving monetary rewards and the likelihood of a household engaging in recycling activities. This finding suggests that financial incentives are a potent motivator for recycling, overshadowing factors such as income and education, which did not show a significant effect. Unlike prior research emphasizing socio-economic status and education, our results indicate that monetary incentives might be more effective in the local context of Panama City.

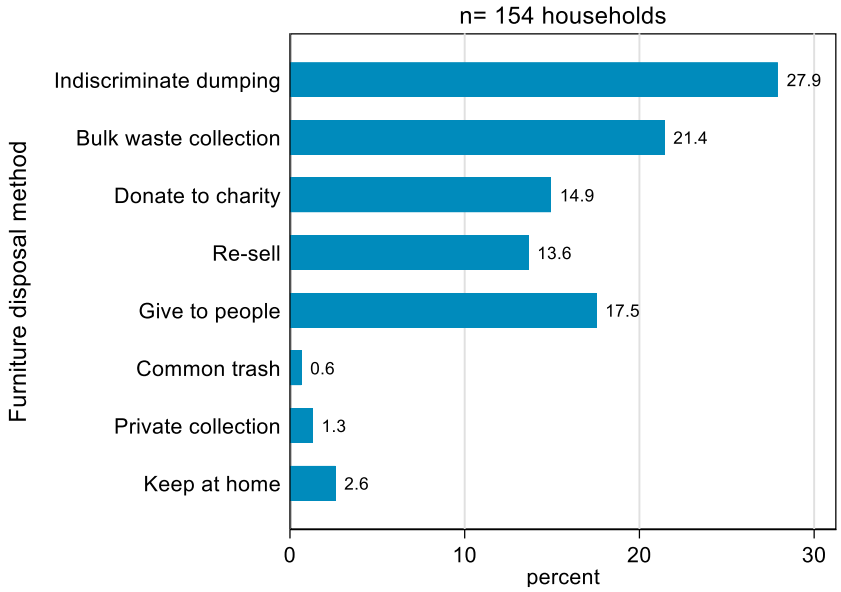
Table A4. Effects of socio-economics characteristics on recycling probability

	Practice recycling
Receive money from recycling	0.868***
	(0.0466)
Main source of information	
National TV news	-0.0436
	(0.0692)
Newspaper (online, physical)	-0.223
	(0.157)
Radio	0.403
	(0.344)
Received any information or training on sorting	0.199
	(0.146)
Log (household income)	-0.0581
	(0.0673)
Age of person in charge of disposing of solid waste	0.00519**
	(0.00243)
Education of person in charge of disposing of solid waste	0.00757
	(0.0100)
Number of members in the household	0.0136
	(0.0124)
Observations	154
R^2	0.322
F	84.12***

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The main source of information reference groups is social media. District controls are included.

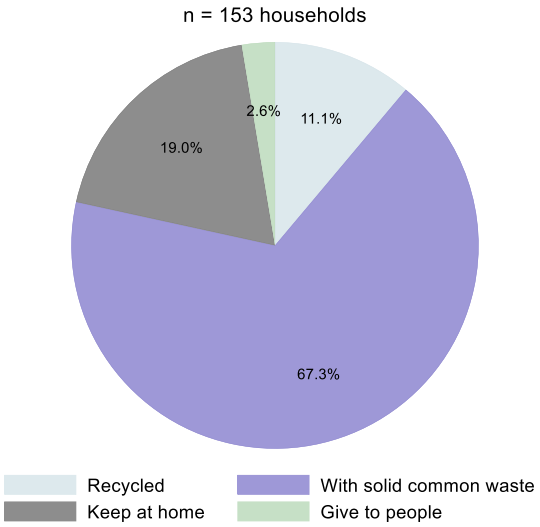
A4. Waste Disposal Characteristics in Panama City

Figure A1. Furniture waste disposal method by households in Panama City.



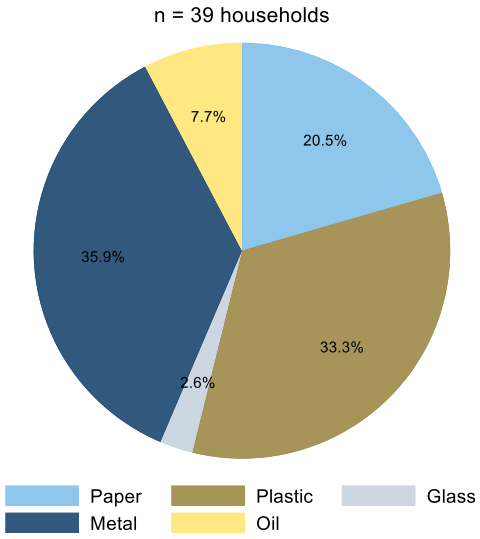
Note: This figure is constructed using data from the Solid Waste Practices Survey of 154 households in Panama City. For our estimation results we compare the households that dump their furniture indiscriminately and those that use any other method.

Figure A2. Electronic waste disposal method by households in Panama City



Note: This figure is created using data from the Solid Waste Practices Survey in Panama City; 153 households reported how they dispose of electronics waste such as televisions, computers, cell phones, etc.)

Figure A3. Recycled materials by households in Panama City



Note: This figure is created using data from the Solid Waste Practices Survey in Panama City, 39 households reported what materials they mainly recycle.

A5. Solid Waste Practices Survey

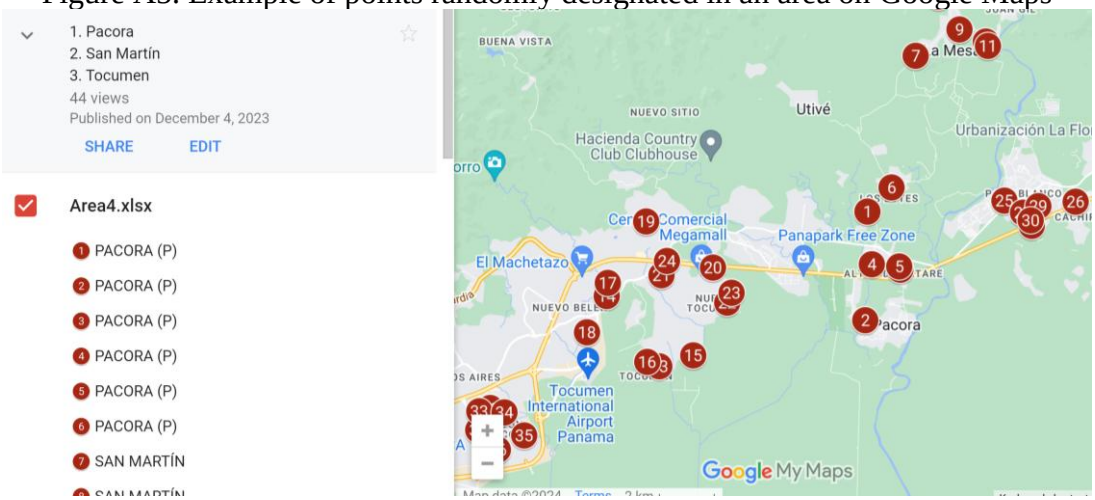
Six random locations within each corregimiento were initially identified for data collection. To facilitate the survey process, we divided the collection task into six designated areas, each assigned to a specific surveyor. The first five areas comprised six corregimientos each, while the sixth area included five, organized based on geographic proximity.

Figure A4. Area of study for solid waste management survey in Panama City

Note: The area includes 35 corregimientos in Panama and San Miguelito districts.

Each surveyor received both oral and written instructions detailing the data collection procedures. They were also provided a cover page outlining key survey points, including a designated area checklist and a QR code to locate the households using Google Maps. The survey instrument contained a brief explanation of the study's objectives and significance and a statement affirming the confidentiality of the responses, which the surveyors were instructed to read aloud at the start of each interview.

Figure A5. Example of points randomly designated in an area on Google Maps



Note: A surveyor accessed this map using the Google Maps application. Points were randomly selected using the Google Earth Engine platform through the code editor tool. After verifying with map layers that the points were located in areas appearing to be residences, further verification was conducted with surveyors during the collection period.

Table A5. Corregimientos included in the waste disposal methods analysis and sample allocation.

		Population (2023)		Disproportionate Stratified Sample Using Equal Allocation		Complete questionnaires
District	Corregimiento	N	%	n	%	n
San Miguelito	Amelia Denis De Icaza	29208	2%	6	2.86	4
	Belisario Porras	44129	3.2%	6	2.86	3
	José Domingo Espinar	44448	3.2%	6	2.86	5
	Mateo Iturralde	9638	0.7%	6	2.86	6
	Victoriano Lorenzo	15181	1.1%	6	2.86	5
	Arnulfo Arias	31433	2.3%	6	2.86	3
	Belisario Frías	33072	2.4%	6	2.86	8
	Omar Torrijos	32403	2.4%	6	2.86	6
	Rufina Alfaro	41265	3.0%	6	2.86	3
Panama	San Felipe	1258	0.1%	6	2.86	5
	El Chorrillo	16335	1.2%	6	2.86	4
	Santa Ana	13495	1.0%	6	2.86	4
	Calidonia	17300	1.3%	6	2.86	2
	Curundú	15458	1.1%	6	2.86	3
	Betania	42199	3.1%	6	2.86	6
	Bella Vista	33710	2.5%	6	2.86	5
	Pueblo Nuevo	24167	1.8%	6	2.86	6
	San Francisco	61290	4.5%	6	2.86	6
	Parque Lefevre	42832	3.1%	6	2.86	5
	Río Abajo	28045	2.1%	6	2.86	6
	Juan Díaz	56583	4.1%	6	2.86	2
	Pedregal	57682	4.2%	6	2.86	4
	Ancón	37224	2.7%	6	2.86	5
	Chilibre	49582	3.6%	6	2.86	6
	Las Cumbres	39923	2.9%	6	2.86	5
	Pacora	70283	5.1%	6	2.86	4
	San Martín	5485	0.4%	6	2.86	5
	Tocumen	89361	6.5%	6	2.86	5
	Las Mañanitas	45241	3.3%	6	2.86	2
	24 De Diciembre	79965	5.8%	6	2.86	4
	Alcalde Díaz	46976	3.4%	6	2.86	4
	Ernesto Córdoba	71613	5.2%	6	2.86	4
	Caimitillo	34097	2.5%	6	2.86	3
	Las Garzas	56980	4.2%	6	2.86	1
	Don Bosco	49906	3.6%	6	2.86	5
	Total	1 367 767	100%	210	100	154

A6. English version of the questionnaire used for survey collection

Title: Waste Management Survey - Perspectives and Attitudes in Panama City

Introduction: *Thank you for participating in this survey. The purpose of this questionnaire is to obtain information on domestic waste management practices, perceptions and attitudes in Panama. Their answers will contribute to academic research aimed at understanding the economic implications of waste management for households. Your responses will remain anonymous and confidential. Answer the following questions to the best of your ability.*

Interviewer's Name: _____

SECTION 1: HOME ADDRESS	
1. District: _____	4. Street or avenue: _____
2. Corregimiento:_____	5. Building House No.: _____
3. Residential area:_____	6. Room or apartment No. _____

SECTION 2: INTERVIEW INFORMATION		
Start Date & Time	Closes: dd/mm _____ time: _____ am/pm	
Respondent's first and last name	**Respondent's relationship to the head of household**	
	□1 Head of household □2 Spouse/partner □3 Child	□4 Another relative □5 Non-relative □6 Domestic Householder

SECTION 3: DEMOGRAPHICS	
1. How long have you been living in this neighborhood? □□ years □□ months ___all your life	5. How many members are in this household? □□
2. How old is the person in charge of disposing of solid waste at home? □□	6. How many people work in this household? □□
3. What is the gender of the person in charge of disposing of the solid waste at home? □ M □ F	7. What is the current employment situation of the head of the household? □ 1 Formal worker* □ 2 Informal worker* □ 3 Doesn't work
4. What grade does the person in charge of disposing of solid waste at home have? □ 1 Primary □ 2 Secondary □ 3 High School □ 4 Technique □ 5 Bachelor's degree □ 6 Mastery □ 7 Doctorate.	***(If the head of the household works)*** 7.1. What is the occupation, or job of the head of the household? *(If you have more than one, write down the one that generates the most income)* _____ 8. How much is the family's monthly income? *(approximate is fine)* B/. _____ 9. How much is the total monthly household expenditure *(including food, housing, utilities, transportation, etc.)* B/. _____

SECTION 4: WASTE MANAGEMENT PRACTICES	
1. How do you dispose of the solid waste in this home? □ 1 Public collection truck. □ 2 Private collection car. □ 3 Incineration or burning. □ 4 Dump in empty land. □ 5 Burial. □ 6 River, stream, lake, the sea. □ 7 Other Way *(Specify)* _____ 2. On average, how often do you dispose of solid waste? □ 1 Diary □ 2 Several times a week □ 3 Once a week □ 4 Less than once a week	3. Do you pay for the solid waste collection service provided by the municipality? □ 1 Yes □ 2 No ***(Only for those who use public <u>and private</u> collection service)*** 4. On average, how often does the solid waste collector come? □1 Several times a week □2 Once a week □3 Once every 2 weeks □4 Other_____ *(specify)* ***(Only for those who use the <u>private</u> collection service)*** 5. If you pay for private solid waste collection services, how much do you typically spend per month? B/. _____

SECTION 5: RECYCLING, DISPOSAL OF ELECTRONICS AND FURNITURE	
1. Do you compost? □ 1 Yes □ 2 No 2. How do you typically dispose of furniture and large items when you no longer need them? □ 1 Dump in the street, community landfill or river. □ 2 Request the municipality's special collection service. □ 3 Donate to charity or thrift stores. □ 4 Sell online or through garage sales. □ 5 Other *(please specify)* _____ 3. How do you dispose of e-waste (televisions, computers, cell phones, etc.) in your home? □ 1 Recycle through authorized e-waste collection programs. □ 2 Disposed with common household waste. □ 3 Keep them at home. □ 4 Other (please specify) _____	4. Are you aware of any recycling stations in your area? □ 1 Yes, very consciously. □ 2 Somehow conscious. □ 3 I don't realize it at all. 5. Do you actively recycle any materials in your home? □ 1 Yes * □ 2 No ***(Only for those who recycle)*** 5.1.What materials do you recycle? *(Check all that apply)* □ 1 Paper, cardboard, tetra packs. □ 2 Plastic □ 3 Glass □ 4 Metal (iron, steel, aluminum, copper, etc.) □ 5 Other *(please specify)* _____ 5.2. Do you receive any monetary incentives for recycling? □ 1 Yes □ 2 No

SECTION 6: FLOODING, DRAIN, WATER AND HEALTH	
1. How do you get the drinking water in this household? □ 1 IDAAN public aqueduct * □ 2 Community public aqueduct * □ 3 Private aqueduct * □ 4 Tanker □ 5 Well well, shallow. □ 6 Other _____(specify) ***(If you answered 1, 2 or 3 in the previous question)*** 1.1. How many days a week do you get drinking water? _____days 1.2. How many hours a day do you get drinking water? _____hours 2. Are there blocked drains on your street when it rains? □ 1 Yes □ 2 No 3. Have you experienced flooding in your area in the last 3 years? □ 1 Yes * □ 2 No	***(Only for those who have experienced flooding)*** 3.1. If yes, how often have you experienced flooding in the last 3 years? □ 1 Once □ 2 Two - three times □ 3 Four to six times □ 4 More than 6 times 4. In the past 3 years, have you or anyone in your household experienced any of the following diseases? □ 1 Malaria □ 2 Acute respiratory infection □ 3 Dengue □ 4 Leishmaniasis □ 5 Yellow fever. □ 6 Zika □ 7 Chikungunya □ 8 Hepatitis A □ 9 Diarrhea

SECTION 7: WASTE MANAGEMENT AWARENESS AND EDUCATION	
1. Have you or any of the household members received any formal education or training on waste management practices? □ 1 Yes □ 2 No 2. Have you ever heard of the "Zero Waste" program? □ 1 Yes □ 2 No	3. How effective do you think the awareness campaigns on waste management (reduce, reuse and recycle) have been? □ 1 Highly effective □ 2 Something Effective □ 3 Not Effective 4. Where do you mainly get your daily news from? □ 1 TV News □ 2 Social media □ 3 Newspaper (online, physical) □ 4 Other (please specify) _____

SECTION 8: ADDITIONAL COMMENTS

Would you like to provide any additional feedback or information about waste management in your home and community?

_____

_____

_____

_____

Thank you for your time and valuable input! Their responses will contribute to a better understanding of waste management practices and their impact on Panamanian households.

End Date & Time
Date: dd/mm_____ hour: _____ am/pm

INTERVIEWER'S OBSERVATIONS:

(Any comments or observations about the interviews or respondents)

_____

_____

_____

_____